# I.

# A háromdimenziós ultrahang-diagnosztika alkalmazásának lehetőségei a szülészet-nőgyógyászatban

**Pál Attila dr., Vajda György dr., Bábinszki Ágota dr. és Kovács László dr.**

Szent-Györgyi Albert Orvostudományi Egyetem Szülészeti és Nőgyógyászati Klinika, Szeged (igazgató: Kovács László dr.)

A szerzők beszámolnak a háromdimenziós ultrahangtechnika alkalmazásával szerzett tapasztalataikról 286 terhes és 35 nőgyógyászati betegségben szenvedő személy ultrahangvizsgálata kapcsán. A vizsgálatokat Combison 530 ultrahangkészülékkel végezték. Kóros elváltozást 14 esetben diagnosztizáltak. Tapasztalataik alapján a három dimenziós technika bevezetése jelentős mértékben javítja mind a praenatalis, mind a nőgyógyászati ultrahang-diagnózisok találati biztonságát, és olyan elváltozások is megjeleníthetők, melyek a hagyományos eljárások mellett korábban nem voltak ábrázolhatók.

*Kulcsszavak:* három dimenziós ultrahang, szülészet-nőgyógyászat

**Possibilities of applying 3 dimensional ultrasound technique in obstetrics and gynecology.** The authors report their experiences with 3 dimensional ultrasound technique applied in cases of 286 obstetrical and 35 gynecological examinations. Combison 530, 3 D ultrasound equipment was used. Pathological signs were found in 14 cases. The introduction of this technique has been increasing the diagnostic accuracy of prenatal and gynecological ultrasound examinations, and some malformations, that could have never been seen by "traditional" 2 D methods, can be visualized as well.

*Key words:* 3 dimensional ultrasound, obstetrics and gynecology

Ahogy a röntgenvizsgálatok bevezetése jelentősen bővítette a diagnosztikus lehetőségek tárházát, a huszadik század második felében bevezetésre került ultrahangvizsgálatok hasonló áttörést eredményeztek a képalkotó eljárások között. Ezt követően folyamatos fejlődés volt tapasztalható, egyre jobb felbontású készülékek jelentek meg, tökéletesítve a leletek találati biztonságát.

Ám a kétdimenziós technika minden esetben csak a vizsgált objektum metszetszerű képét adta, és a mindenkori vizsgáló csak fejben tudta a metszetekből – a vizsgálófej mozgatásával – rekonstruálni a vizsgált objektum térbeli képét. Ez természetesen több diagnosztikus nehézséget, illetve tévedést okozott.

A komputertechnika és az ultrahang-diagnosztika fejlődésével, valamint ezek összekapcsolásával lehetőség nyílt a három dimenziós (3 D) ultrahangvizsgálatok technikai feltételeinek megteremtésére (3, 4, 7, 10).

A világon a 3 D vizsgálatok megjelenése kb. 10 éves múltra tekint vissza. Több szerző véleménye szerint az ultrahangvizsgálatok vonatkozásában a 3 D technika bevezetése olyan diagnosztikus áttörést jelent, mint a radiológiai vizsgálatok kapcsán a komputertomográfia alkalmazása volt (3, 8, 9, 10).

A Szent-Györgyi Albert OTE Női Klinikáján 1996 januárjától áll rendelkezésre ilyen ultrahangkészülék, így a szülészet-nőgyógyászatban – hazánkban elsőként – szeretnénk beszámolni tapasztalatainkról. Arra kívántunk választ kapni, miként illeszthető a napi rutin ultrahangvizsgálatok sorába a háromdimenziós ultrahangtechnika, valamint milyen diagnosztikus előnyöket jelent a hagyományos eljárással szemben.

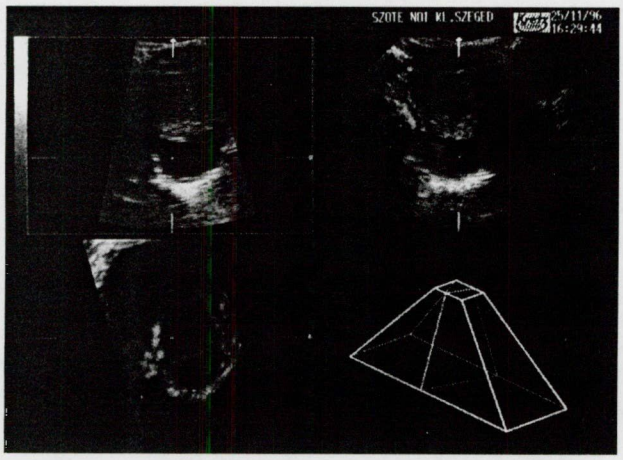
## Anyag és módszer

A Szent-Györgyi Albert OTE Női Klinikáján 286 terhes, és 35 nőgyógyászati beteg ultrahangvizsgálata történt 1996. január és november között a Kretztechnik Combison 530 típusú ultrahangkészülékével, mely három dimenziós (3 D) rekonstrukcióhoz szükséges transducerekkel és komputerprogrammal rendelkezik, így a vizsgált objektum térbeli képe a készülék képernyőjén néhány perc alatt külön készülék közbeiktatása nélkül megjeleníthető és megmérhető. A vizsgálatokhoz 3,5–5 MHz-es transabdominalis, illetve 5–7,5 MHz-es transvaginalis volumetriás vizsgálófejeket használtunk.

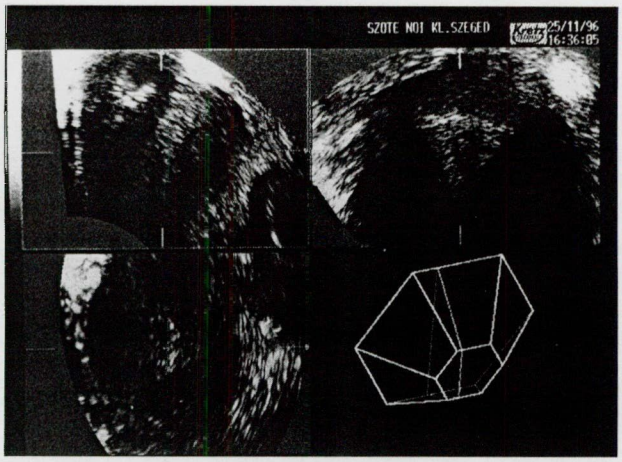
A vizsgálatok alkalmával minden egyes beteg esetében kétdimenziós (2 D) ultrahangvizsgálatot végeztünk, majd ezt követően történt a 3 D vizsgálat. A háromdimenziós ultrahangtechnika a betegek számára semmilyen többlet megterhelést nem jelentett, mivel a vizsgálófej energiakibocsátása megegyezik a hagyományos kétdimenziós vizsgálófejével, ám az expozíciós idő, mely a volumen leképezéséhez szükséges, csupán néhány másodperc volt.

### *A vizsgálati módszer rövid ismertetése*

A háromdimenziós rekonstrukció kapcsán a Combison 530 ultrahangkészülék a transabdominalis fej esetében egy virtuális téglalap alapú *(1. ábra)*, illetve a transvaginalis fej esetében egy hatszögű csonka gúlán belül *(2. ábra)* – melynek csúcspontjában maga a vizsgálófej helyezkedik el – meghatározott idő alatt (2–13 sec) tetszőlegesen választott helyzetű és méretű volument képez le (max. 2500 $cm^3$), melynek minden egyes pontja tárolódik. Az így rögzített volumenen belül egy térbeli koordináta-rendszernek megfelelően bármely tetszőleges sík kiválasztható, és szabadon – akár 360 fokban is – elforgatható. A megjelenítés kapcsán 3 irányból – frontális, transzverzális és coronalis síkban – ábrázolódik a vizsgált képlet, mely síkok alapján elvégezhető ezen objektum három dimenziós felszíni, illetve a rtg-képhez hasonló, a belső volumen szerkezetetét is bemutató, úgynevezett translucens térbeli rekonstrukciója.




**1. ábra:** A transabdominalis 3 D vizsgálófejjel felvett téglalap alapú csonka gúlán belül (jobb alsó kép) rögzített volumen tetszőlegesen kiválasztott pontjai 3 síkban – frontális (bal felső kép), transzverzális (jobb felső kép) és coronalis (bal alsó kép) – ábrázolhatók. Az ábrán follicolusok láthatók az említett metszetekben




**2. ábra:** Az ábrán transvaginalisan – hatszög alakú csonkagúla-volumenben (jobb alsó kép) – felvett endometrium képe látható az *1. ábra* kapcsán már ismertetett 3 síkban

A felszíni rekonstrukciós eljárás inkább a folyadék/szilárd felület határának ábrázolására (pl. arc, végtagok stb.), míg a translucens mód inkább a belső szervek, illetve csontok (pl. gerinc) vizsgálatára alkalmazható.

Ezen eljárás olyan lehetőségeket nyújt már a rekonstrukciós technika alkalmazása nélkül is például a gerinc vizsgálata kapcsán, hogy a három alapmetszetben egyszerre lehet látni a gerinc hosszanti, oldalirányú és harántmetszeti képét, melyre korábban a hagyományos módszerek alkalmazásával nem volt mód. A coronalis metszet az új vizsgálati nézet, melyet a gép az egymást követő sorozatmetszetek alapján számol ki és jelenít meg, tehát ábrázolására csak ezzel az eljárással van lehetőség. Bármely rögzített sík vizsgálatakor a komputertomográfhoz hasonló rétegfelvételek készíthetők gyakorlatilag azonnal, s így metszetről metszetre lehet vizsgálni a kívánt testrészt vagy szervet (pl. a magzati hátgerincet), ezáltal egyszerűbben felismerhető az egyébként nehezebben vizsgálható elváltozás.

Továbbá az eddig csak becslésen alapuló térbeli kiterjedések nagy pontosságú mérésére nyílik lehetőség, jól reprodukálható módon lehet pl. a tumorszövet mennyiségének változását ellenőrizni.

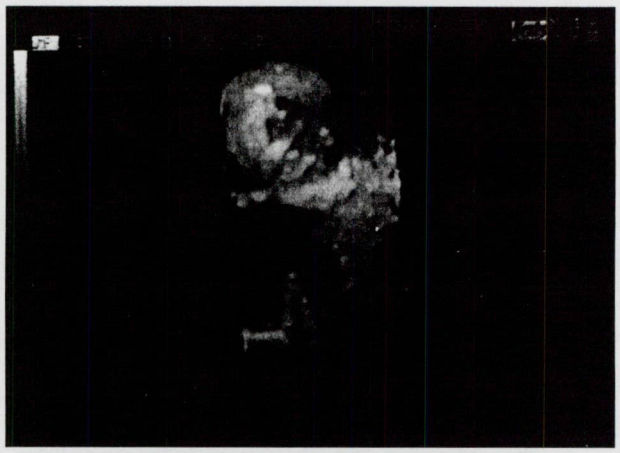
Az elektronikus tárolás lehetőséget ad az egész vizsgált volumen rögzítésére, ezáltal a beteg ismételt vizsgálata nélkül, a tárolt adatokon belül szintén bármely sík, felszín vagy szerv szabadon rekonstruálható, tanulmányozható és mérhető. A kérdéses esetet több kolléga láthatja a beteg további megterhelése nélkül. Az eredmények ezáltal összehasonlíthatóvá válnak és tudományos, illetve oktatási célokra is kiválóan felhasználhatók.

## Eredmények

A vizsgált betegek különböző diagnózisok szerinti megoszlását az *1. táblázatban* foglaltuk össze. Az első trimeszterbeli transvaginalis vizsgálatok az ébrény morfológiájáról könnyen áttekinthető képet adtak. Jól megfigyelhetők voltak a finom embrionális struktúrák is *(3. ábra)*. Az embrionális részek nagy pontosságú tanulmányozása lehetséges, ezáltal is segítve a pontosabb diagnózist.

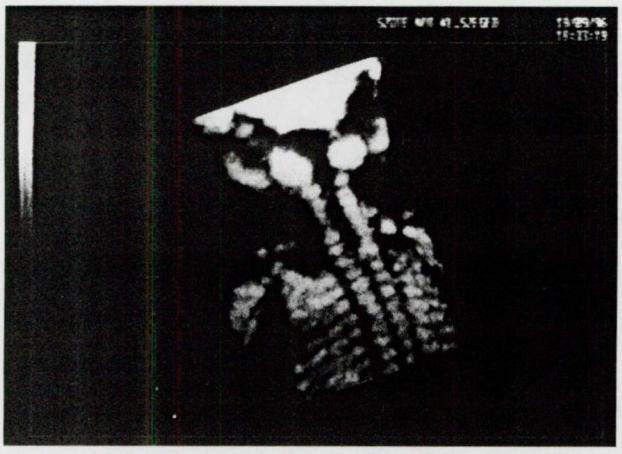
**1. táblázat:** A három dimenziós UH technikával vizsgált esetek megoszlása

| Esetek megoszlása | Esetszám | Kóros esetek száma |
|---|---|---|
| I. trimeszter | 89 | 2 |
| II. trimeszter | 102 | 5 |
| III. trimeszter | 95 | 3 |
| Nőgyógyászati | 35 | 4 |
| Összesen | 321 | 14 |

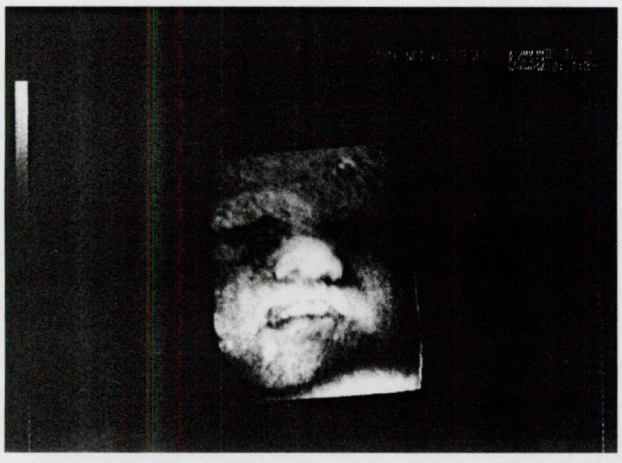


**3. ábra:** 12 hetes magzat 3 D képe, melyen bal profilból látható a magzat feje, karja, törzse és lába

A második trimeszterben, a genetikai ultrahangvizsgálatok kapcsán, a vizsgálóra nagy felelősség hárul a terhesség további sorsát illetően. Kérdéses esetekben már a különböző metszetek alkalmazásának lehetősége is nagy előnyt jelent. Nem kell minden alkalommal a rekonstrukciót választani, pl. a magzati gerinc vizsgálata esetében elegendő a kérdéses csigolyák coronalis metszeti képének megtekintése *(4. ábra)*. Továbbá lényegesen egyszerűbb a magzati arc-diszmorfiák felismerése és pontosabb meghatározása. Ezen technika segítségével lehe-



**4. ábra:** 3 D rekonstrukcióval készült magzati csontváz. Jól ábrázolódnak a koponyacsontok, csigolyák, lapockák, kulcscsontok, bordák, felkarcsontok



**5. ábra:** A képen egy 37 hetes magzat arcának 3 D képe látható. A módszer segítségével – megfelelő feltételek mellett – a magzati arc részletei jól megfigyelhetők, és az esetleges elváltozások könnyebben felismerhetők

**6. ábra:** Transvaginalis vizsgálófejjel rögzített normál endometrium 3 D képe

tőségünk volt egy kétdimenziós technikával méhen belüli húrszerűnek látszó képletről meghatározni, hogy csupán egy abnormálisan elhelyezkedő cotyledóról van szó.

A harmadik trimeszterben minden olyan esetben, ahol a hagyományos kétdimenziós eljárás gyanús elváltozást vetett fel, illetve nem adott egyértelmű eredményt, a 3 D alkalmazása segítséget jelentett. Így a későbbiekben felismert nyúlajak, szájpadhasadék kétséget kizáróan igazolható volt *(5. ábra)*. Megjegyezzük, hogy azokban az eseteinkben, ahol a tehesség oligohydramnionnal szövődött, a felszíni rekonstrukció sokszor rendkívül nehéz vagy kivitelezhetetlen volt. A kérdéses magzatrészt gyakran árnyékolta az uterus fala, magzati aprórész vagy a placenta. Ilyenkor a vizsgálatot később megismételtük.

Nőgyógyászati vizsgálatok kapcsán mind a transvaginalis mind a transabdominalis fej jól alkalmazható. Ilyen esetekben nem a felszíni rekonstrukciót, hanem a szövettömegek, belső szervek megjelenítésére alkalmas ún. translucencia módot választottuk, melyben a kép a rtg-képhez volt hasonló *(6. ábra)*. Így a kismedencei szervek, uterus fejlődési rendellenességek, az endometrium elhelyezkedése, vastagsága, illetve az adnexumok meghatározása vált lehetségessé.

Kismedencei tumorok esetében a volumetriás móddal a tumorszövet pontos kiterjedése, esetleges más szervvel való kapcsolata vizualizálható, és a 3 D kép tárolásával az esetleges kezelés során (pl. cytostaticus terápia az ováriumtumorok esetében) a daganatszövet tömegének változása meghatározható, illetve ellenőrizhető.

## Megbeszélés

A modern vizsgálóeljárások fejlődésével egyre nagyobb reális igény mutatkozik az orvostudomány minden területén a minél pontosabb diagnózisra. Emellett szintén fontos törekvés, hogy a beteget minél kisebb megterhelésnek tegyük ki.

Az ultrahang-diagnosztika a képalkotó eljárások sorában a legkevésbé számít invazívnak. A 3 D technika megjelenése lehetővé tette, hogy az eddig csak síkmetszeti képben történő ábrázolás helyett, a metszetek komputer segítségével tárolt halmazában a vizsgáló a térben szabadon tájékozódjon, és egy adott szerv vagy testrész nagy pontosságú három dimenziós képét készítse el már néhány pillanat alatt (2, 3, 5). A komputerben rögzített térfogat alapján a későbbiekben is bármely tetszőleges sík kiválasztható, megjeleníthető, és szükség szerint 3 D rekonstrukció végezhető. Ezáltal összehasonlító vizsgálatok is végezhetőek (9–11).

A háromdimenziós rekonstrukció alkalmazása módot ad olyan finom részletek nagy pontosságú megfigyelésére, melyek hagyományos technika mellett nem vagy csak nehezen ítélhetők meg. A módszer segítségével a vizsgált objektum különböző szögből történő megtekintése és megmérése is lehetséges, mely a találati biztonságot nagymértékben fokozza (1, 2, 6, 7). Az elektronikus tárolás előnye, hogy a vizsgáló a beteg jelenléte nélkül is részleteiben tanulmányozhatja a volumenen belüli kérdéses objektumot, s így a betegre jutó megterhelés viszonylag csekély. Lehetőség van a kérdéses elváltozás több szakember által történő megtekintésére is (7, 8).

A nemzetközi irodalmi adatok alapján, melyet lelkesítő személyes tapasztalataink is megerősítettek, ezen új eljárás fontos szerepet kaphat a szülészetben, mind a korai embrionális, mind a későbbi magzati rendellenességek pontos kórismézésében, valamint nőgyógyászati alkalmazása új, széles körű diagnosztikus lehetőségeket teremt (1, 2, 5–7).

Kellő számú eset tapasztalatai alapján további vizsgálatainkban részletes összehasonlító elemzéssel szeretnénk e diagnosztikus módszer helyét a mindennapi gyakorlatban meghatározni.

IRODALOM: 1. *Budorick, N. E., Pretorius, D. H., Nelson, T. R.:* Sonography of the fetal spine: technique, imaging findings, and clinical implications. Am. J. Roentgenol., 1995, *164,* 421–428. – 2. *Devonald, K. J., Ellwood, D. A., Griffiths, K. A. és mtsai:* Volume imaging: three dimensional appreciation of the fetal head and face. J. Ultrasound. Med., 1995, *14,* 919–925. – 3. *Hamper, U. M., Trapanotto, V., Sheth, S. és mtsai:* Three dimensional US: preliminary clinical experience. Radiology., 1994, *191,* 397–401. – 4. *Kelly, I. M., Gardener, J. E., Lees, W. R.:* Three dimensional fetal ultrasound [letter]. Lancet, 1992, *339,* 1062–1064. – 5. *Lee, A., Deutinger, J., Bernaschek, G.:* Three dimensional ultrasound: abnormalities of the fetal face in surface and volume rendering mode. Br. J. Obstet. Gynaecol., 1995, *102,* 302–306. – 6. *Lee, A., Kratochwil, A., Deutinger, J. és mtsai:* Three dimensional ultrasound in diagnosing phocomelia. Ultrasound Obstet Gynecol., 1995, *5,* 238–240. – 7. *Merz, E., Bahlmann, F., Weber, G.:* Volume scanning in the evaluation of fetal malformations: a new dimension in prenatal diagnosis. Ultrasound Obstet. Gynecol., 1995, *5,* 222–227. – 8. *Merz, E., Bahlmann, F., Weber, G. és mtsai:* Three dimensional ultrasonography in prenatal diagnosis. J. Perinat. Med., 1995, *23,* 213–222. – 9. *Sohn, C.:* The advantages of spatial, three dimensional ultrasound imaging in clinical application. Bildgebung., 1994, *61,* 87–94. – 10. *Sohn, C., Bastert, G.:* 3D ultrasound in prenatal diagnosis. Z. Geburtschilfe Perinatol., 1993, *197,* 11–19. – 11. *Steiner, H., Spitzer, D., Weiss, Wichert, P. H. és mtsai:* Three dimensional ultrasound in prenatal diagnosis of skeletal dysplasia. Prenat. Diagn., 1995, *15,* 373–377.

(Pál Attila dr., *Szeged,* Pf.: 438, 6700)

## *A Magyar Kísérletes és Klinikai Farmakológiai Társaság meghirdeti*

# *az 1997-es évi „Év Gyógyszere Díj" pályázatát*

A Magyar Kísérletes és Klinikai Farmakológiai Társaság (MFT) „Év Gyógyszere" díjat alapít. A díj Asszonyi Tamás szentendrei képzőművész úr által megalkotott nagyméretű bronz dombormű és kísérő oklevél formájában jelenítődik meg. A védjeggyel levédett díj megalapítását az MFT azon szándéka vezérelte, hogy a Társaság szakmai presztízsével segítse elő azt a nemes célt, hogy hazánkban így egy-egy betegség gyógyításában a legkorszerűbb, leghatékonyabb és leginkább betegbarát készítmények terjedjenek el, új terápiás eljárások honosodjanak meg.

### *Pályázati feltételek*

1. Pályázhatnak a Magyarországon bejegyzett gyógyszergyártó és forgalmazó cégek.
2. Pályázni lehet azon gyógyszerkészítménnyel, melyet Magyarországon törzskönyveztek és amely forgalombahozatali engedéllyel rendelkezik. További feltétel, hogy a gyógyszerkészítmény Magyarországon 5 évnél nem régebben került (kórházi és/vagy patikai) forgalomba.
3. A pályázatnak tartalmaznia kell azokat a gyógyszerre vonatkozó lényegi adatokat, melyek alapján a gyógyszer az OGYI-nál a törzskönyvi- és forgalombahozatali engedélyt megkapta, továbbá az azóta szerzett újabb ismeretek rövid összefoglalását is. Fel kell tüntetni a törzskönyvi engedélyezés és a forgalombahozatal számát és dátumát is.
4. Külön csatolt oldalon (A4, 1 oldal) kell a pályázónak röviden összefoglalnia annak indoklását, hogy a gyógyszer miért jelent lényeges előrelépést az adott terápiás területen (pl. új hatásmód, kevesebb mellékhatás, kedvezőbb és/vagy olcsóbb kiszerelés, stb.)
5. A pályázatot 2 példányban kell eljuttatni az alábbi címre:
   Dr. Kecskeméti Valéria főtitkár, Magyar Kísérletes és Klinikai Farmakológiai Társaság, 1445 Budapest, Pf. 370.
6. A beérkezett pályázatokat az MFT vezetősége által felkért, az adott szakterületen vezető szakértőkből álló ad hoc bizottságok bírálják el. A szakértők száma bizottságonként 3 fő. A szakértők nem állhatnak Magyarországon bejegyzett gyógyszergyártó és forgalmazó céggel alkalmazotti viszonyban.
7. A bizottságok írásos véleménye alapján a díj odaítélésére vonatkozó döntést az MFT vezetősége hozza.
8. Adott tárgyévben egy díj adható ki. Az MFT vezetőségének joga van adott évben a díj kiadását szüneteltetni.
9. A pályázatok benyújtásának határideje: 1997. november 30.
10. Eredményhirdetés időpontja és helye: 1998. február, Hotel Kempinski. A pontos időpontról a médián keresztül küld a társaság értesítést. Az ünnepélyes díjátadás az MFT és a díjazott cég közös rendezésében valósul meg.

Budapest, 1997. szeptember.

*Dr. Kecskeméti Valéria*
*egyetemi tanár*
*a Társaság főtitkára*

# II.

FERTILITY AND STERILITY®
VOL. 71, NO. 6, JUNE 1999

Published by Elsevier Science Inc.
Printed on acid-free paper in U.S.A.

# Diagnosing amnionicity at 6 weeks of pregnancy with transvaginal three-dimensional ultrasonography: case report

*Agota Babinszki, M.D., Tanmoy Mukherjee, M.D., Thomas Kerenyi, M.D., Richard L. Berkowitz, M.D., and Alan B. Copperman, M.D.*

*Division of Reproductive Medicine, Department of Obstetrics, Gynecology and Reproductive Sciences, Mount Sinai School of Medicine, New York, New York*

**Objective:** To report a case of monochorionic, diamniotic twin pregnancy diagnosed at 6 weeks of pregnancy with three-dimensional (3D) transvaginal sonography and to discuss the use of this diagnostic method in the evaluation of multifetal pregnancy in the first trimester.

**Design:** Case report.

**Setting:** University-based IVF program.

**Patient(s):** A 30-year-old ovum recipient underwent ultrasonographic evaluation of a first-trimester twin pregnancy.

**Intervention(s):** Two-dimensional (2D) and 3D transvaginal sonography.

**Main Outcome Measure(s):** Accurate diagnosis of chorionicity and amnionicity.

**Result(s):** Monoamniotic pregnancy and conjoined twinning could not be ruled out by using 2D transvaginal sonography at 6 weeks, because only one yolk sac (YS) and no membranes could be visualized, and the two embryos were closely positioned within one gestational sac. Applying 3D technique, two YSs and two separate embryos could clearly be observed, establishing the correct diagnosis of a monochorionic, diamniotic pregnancy.

**Conclusion(s):** The 3D transvaginal ultrasonography provides a quick and accurate diagnostic modality for the evaluation of a first-trimester multiple gestation. (Fertil Steril® 1999;71:1161–4. ©1999 by American Society for Reproductive Medicine.)

**Key Words:** Monochorionic, pregnancy, multiple gestation, three-dimensional ultrasonography, ovum donation

Received October 20, 1998; revised and accepted January 26, 1999.

Reprint requests: Alan B. Copperman, M.D., Division of Reproductive Endocrinology, Department of Obstetrics, Gynecology, and Reproductive Science, Box 1170, Mount Sinai Medical Center, One Gustave L. Levy Place, New York, New York 10029 (FAX: 212-534-6289; E-mail: acopperman@smplink.msmc.edu).

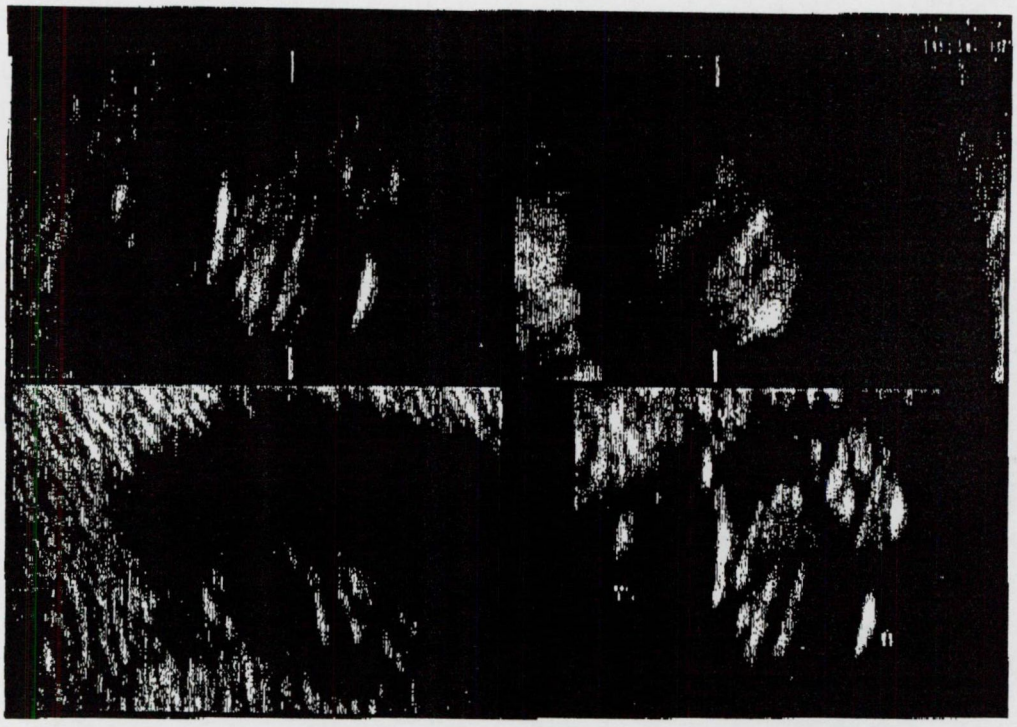
0015-0282/99/$20.00
PII S0015-0282(99)00132-6

The proportion of multiple gestations has been increasing during the past decade with the development of assisted reproductive techniques. Multifetal pregnancy carries an elevated risk for perinatal morbidity and mortality. Moreover, chorionicity and amnionicity also have significant effects on perinatal outcome. The most frequent complications of monochorionic pregnancies are prematurity, fetal malformations, and twin–twin transfusion syndrome (1). In cases of monoamnionicity, conjoined twinning is one of the most difficult abnormalities to manage for the parents and the physicians. Determination of chorionic and amniotic status as early as possible, therefore, is important for the management of the pregnancy and for the prediction of potential perinatal complications (1, 2).

Transvaginal ultrasonography has revolutionized physicians' ability to evaluate early embryonic and extraembryonic features (1). Sonographic evaluation of first-trimester pregnancies are usually performed with the two-dimensional (2D) technique; however, occasionally, some structures cannot be visualized for some time, or their accurate evaluation takes a great deal of time. Most of these difficulties can be eliminated by using the three-dimensional (3D) technology, and several promising results have been published on this issue during the past few years (3, 4).

**FIGURE 1**

A monochorionic, diamniotic twin pregnancy at 6 weeks is displayed in three perpendicular planes. Two yolk sacs, two separate embryos, and an identifiable amniotic membrane can be seen clearly. *Bottom right:* A 3D view also can be displayed simultaneously with the 2D images, allowing constant visualization of each plane during rotation and translation of the 3D image. YS = yolk sac; A = amnion.



We report a case of monochorionic, diamniotic twin pregnancy initially diagnosed at 6 weeks of pregnancy with 3D transvaginal ultrasonography, and we discuss the potential use of this technology in the evaluation of early multifetal pregnancy.

## CASE REPORT

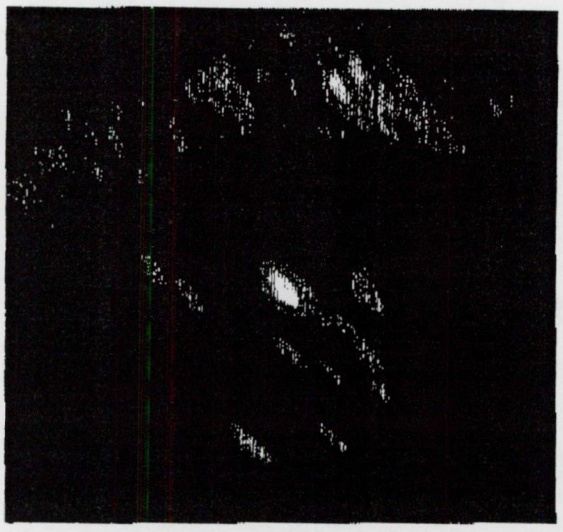
A 30-year-old, para 0, female patient was referred to our program with a 2-year history of infertility. The patient had had 5 years of amenorrhea since stopping hormone replacement therapy. She had received whole-abdomen irradiation at the age of 3, along with ileocolectomy because of reticular cell sarcoma of the small intestine. Uterine atrophy was diagnosed by hysterosalpingography, and sounding of the uterus revealed a distance of 4.5 cm from external os to fundus.

After standard uterine preparation using $E_2$ and intramuscular progesterone, the patient's partner's sperm was used to fertilize donor oocytes in vitro. Three embryos were transferred into the patient's uterine cavity under sonographic guidance, and 11 days later, the patient was found to have an hCG level of 64 μg/mL. She continued to take progesterone supplementation. The first sonographic examination was on the 18th day after ET, with a 2D transvaginal probe (7.5 MHz), and one 5 × 7-mm gestational sac was found inside the uterus. On the next ultrasonography (on day 33 after ET) only one yolk sac (YS) and two closely positioned embryos were observed, each with early cardiac activities, and no amniotic membrane could be visualized by the conventional transvaginal 2D technique.

Because amnionicity could not be determined and conjoined twinning could not be excluded, the 6.5-MHz three-dimensional (3D) transvaginal probe was applied (S-VDW5-8; Kretztechnik, Zipf, Austria) connected to a Voluson 530D ultrasonographic machine (Medison America, Pleasanton, CA). With use of the 3D technique, two yolk sacs and two separate embryos could clearly be demonstrated by rotation and systematic translation of the three perpendicular planes that appear simultaneously on the screen (Fig. 1). The two umbilical cords entered into one placental site. In addition, surface rendering of the contents of the gestational sac was helpful in the diagnosis of mono-

FIGURE 2

A 3D surface rendered view of the monochorionic, diamniotic twin pregnancy at 6 weeks. By rotating this image, conjoined twinning could be excluded.



chorionic, diamniotic twin pregnancy (Fig. 2). Parts of the amniotic membrane also could be observed, although their position could not be visualized unambiguously (Figs. 1 and 2).

The diagnosis was confirmed with another 3D transvaginal sonograpic examination on day 46 after ET (Fig. 3). After that consultation, the patient was referred to her obstetrician for further follow-up. Sonography at 11 weeks found two live embryos corresponding in size to dates based on ET and last menstrual period. A single anterior wall placenta and a monochorionic, diamniotic twin pregnancy was described. Nevertheless, at 12 weeks, no fetal heart motion was seen in either of the fetuses.

## DISCUSSION

Early and accurate diagnosis of a chorionic and amniotic type of multifetal pregnancy can be difficult and may require repeated or time-consuming sonographic examinations, which occasionally will not be tolerated well by pregnant women who have already gone through extensive assisted reproductive procedures. By establishing the diagnosis as soon as possible, an appropriate management strategy can be implemented at the earliest possible time.

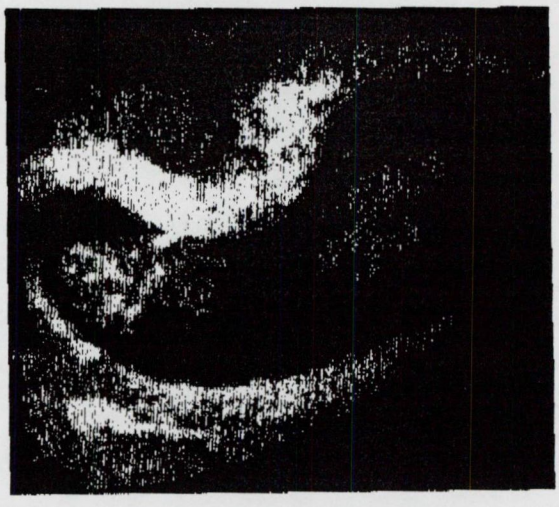
Three-dimensional ultrasonography provides an improved spatial vision for the sonographer by allowing the possibility of simultaneous visualization of the region of interest in three perpendicular planes (3, 4) (Fig. 1). Moreover, these planes can be rotated (by 360 degrees) and translated unlimitedly, which means that the structures inside the acquired volume can be examined with a tomographic precision. The selected volume can be stored permanently after the acquisition, and it can be retrieved for further analysis and comparison any time. Thus, the duration of examination is decreased, whereas the stored images can be analyzed in detail without the presence of the patient. A 3D rendering is also possible by different algorithms (e.g., surface, transparency, and roentgenogram rendering modes), which provides enhanced diagnostic precision in several anatomic situations (Fig. 2).

To date, there are few studies that report examinations of multiple gestation using 3D sonography (4). Hata et al. (4) described 3D sonography as a useful method to study interrelationships and contacts of twin and triplet embryos and fetuses. The efficiency of 2D transvaginal ultrasonography in such cases also has been demonstrated in numerous previous publications (1, 2). Several ultrasonographic findings were suggested to aid in the diagnosis of chorionicity and amnionicity in the first trimester, including the number of placental sites, thickness of membranes, and the presence or absence of the "lambda sign." Nevertheless, evaluation of YS number was reported to have the best diagnostic value for the determination of amnionicity (1, 2). Bromley and Benacerraf (2) demonstrated the correlation between the number of YSs and amnions.

In the case described herein, our ability to accurately diagnose amnionicity and to rule out conjoined twinning enabled us to reassure the patient as early as 6 weeks 5 days of pregnancy. On day 33 after ET only one YS and two closely positioned embryos could be visualized in one ges-

FIGURE 3

Surface rendered 3D image of the embryos at 8 weeks within the same gestational sac, but in two separate amniotic sacs.



tational sac with the transvaginal 2D technique, raising the question of a monoamniotic, and possibly, a conjoined-twin pregnancy. By applying 3D transvaginal ultrasonography at that time and rotating and translating the planes inside the acquired volume containing the whole gestational sac, two YSs and two separate embryos could be identified clearly, and a monochorionic, diamniotic twin pregnancy could be diagnosed. On day 46 after ET, two amniotic cavities were visualized, confirming the diagnosis. Unfortunately, the pregnancy ended with intrauterine demise of both fetuses at 12 weeks.

By the presentation of this case, our goal is not to initiate a kind of "race" for the earliest diagnosis of amnionicity in monochorionic multiple gestation, but to emphasize the diagnostic advantages of 3D sonographic technology over its 2D counterpart, when the visualization of structures in the region of interest are limited, making the examination lengthy or impossible with the conventional method. On the basis of our experience with 3D ultrasonography, we believe that it is a quick, simple, and possibly, a more accurate diagnostic modality than 2D sonography to evaluate the multifetal pregnant uterus in the first trimester. It is our impression that it may have value as an alternative or supplement to traditional 2D sonography in selected and high-risk cases in the future.

*Acknowledgment:* The authors thank Medison America, Pleasanton, California, for their generosity in allowing us to use this 3D ultrasonographic machine for educational purposes.

## References

1. Monteagudo A, Timor-Tritsch IE, Sharma S. Early and simple determination of chorionic and amniotic type in multifetal gestations in the first fourteen weeks by high frequency transvaginal ultrasonography. Am J Obstet Gynecol 1994;170:824–9.
2. Bromley B, Benacerraf B. Using the number of yolk sacs to determine amnionicity in early first trimester monochorionic twins. J Ultrasound Med 1995;14:415–9.
3. Bonilla-Musoles F, Raga F, Osborne NG, Blanes J. Use of three-dimensional ultrasonography for the study of normal and pathologic morphology of the human embryo and fetus. J Ultrasound Med 1995; 14:757–65.
4. Hata T, Aoki S, Miyazaki K, Iwamari O, Sawada K, Tagashira T. Three-dimensional ultrasonographic visualization of multiple pregnancy. Gynecol Obstet Invest 1998;46:26–30.

# III.

*Ultrasound Obstet Gynecol* 2000; 15: 341–344.

# Letters to the Editor

## Three-dimensional color power angiography of an aneurysm of the vein of Galen

Continued rapid progress in the development of computer technology has recently enabled the intrauterine three-dimensional visualization of fetal vessels. Three-dimensional rendering is based on the principles of the color power imaging technique, which provides color-coded information on the blood flow within a defined segment depending on the intensity of the Doppler signal after reflection and scattering. In contrast to conventional color Doppler sonography, where Fourier transformation is used to analyze the frequency spectrum, color power imaging permits an evaluation of signal amplitude. Three-dimensional color power imaging of vessels represents a further development of this technique and is based on the following principle: the volume of interest is initially rendered in the two-dimensional color power mode. On optimum visualization, the transducer is swept across the area of interest using a free-hand technique. The acquired volume contains a number of cine-loop sequences with defined two-dimensional slices. Three-dimensional visualization of the vessels can be calculated from the acquired volume by special software integrated into the ultrasound device, and impressively rendered on the ultrasound monitor by on-line rotation. There is no doubt that the introduction of this new ultrasound technology will have a significant impact on the diagnosis of fetal vascular anomalies. In the reported case of an aneurysm of the vein of Galen an ultrasound device (HDI 5000, ATL Solingen, Germany) with integrated three-dimensional color power angio software was used for three-dimensional vessel reconstruction (Figure 1). The investigation was carried out with an electronic broad-band curved array 4–2 MHz transducer. A 7–4 MHz transducer was used for real-time color power Doppler imaging and subsequent three-dimensional reconstruction.

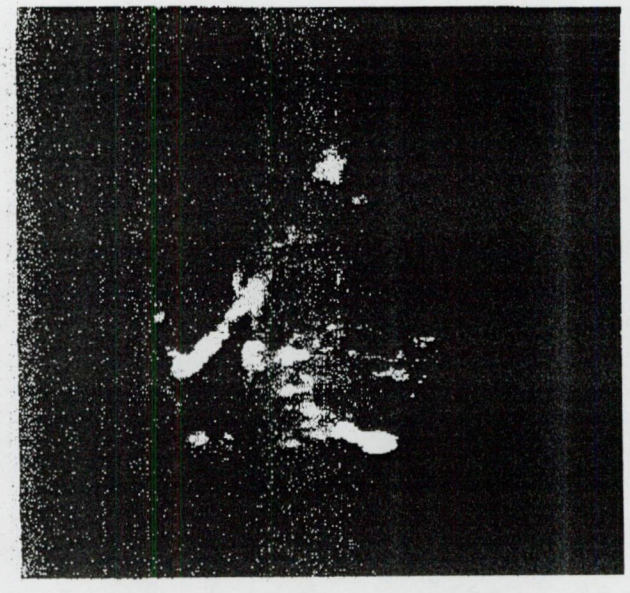


Figure 1 A three-dimensional intrauterine color power image of an aneurysm of the vein of Galen at 32 + 1 weeks' gestation.

We report a case of aneurysm of the vein of Galen at 32 weeks' gestation. Presentation for detailed prenatal diagnosis was recommended in the presence of a cerebral cystic mass with poor echogenicity. On conventional color Doppler examination a pronounced circular multicolored mosaic pattern was observed immediately anterior to the thalamus and at the level of the middle cerebral artery. Transplacental digitalization was initiated at 35 weeks' gestation due to both an early systolic tricuspid insufficiency and borderline cardiomegaly. The pregnancy continued until 39 weeks' gestation when an elective Cesarean was carried out. A female was delivered, birth weight 348 g and Apgar scores of 5, 7 and 8 at 1, 5 and 10 min. The cord pH was 7.32. The prenatal diagnosis of aneurysm of the vein of Galen was confirmed on postnatal sonography. The neonatal period was complicated primarily by haemodynamic instability due to a substantial increase in shunt volume. Embolization of the arteriovenous shunt connections was performed on parental request, and successfully completed after the second attempt. Circulatory conditions subsequently returned to normal. The child showed satisfactory neuromotor findings at the time of neurological evaluation 12 months after the intervention.

F. Bahlmann
*Johannes Gutenberg Clinic,*
*University of Mainz,*
*Mainz,*
*Germany*

## Diagnosis of Asherman's syndrome with three-dimensional ultrasound

Amenorrhea traumatica (Asherman's syndrome) is the presence of intrauterine adhesions caused by the destruction of different parts of the endometrium. This causes secondary amenorrhea, hypo-, oligo-, dysmenorrhea, lower abdominal pain, sterility and infertility. The correct diagnosis, discovery of location and differentiation are very important for planning the right therapy. In the case presented here, Asherman's syndrome was diagnosed on the basis of the symptoms and the result of hysterosalpingography (HSG), but it was also confirmed by transvaginal three-dimensional ultrasound examination.

A 36-year-old woman (gravida 1, para 0) underwent an abortion in January 1996, after which she was treated with

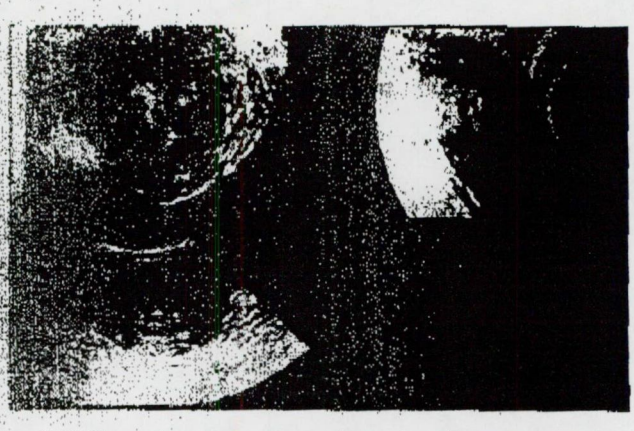


Figure 1 The endometrium can be observed in three perpendicular planes using 3D ultrasound. The echo-free area in the endometrium corresponds to the area that was *not* filled with contrast fluid during the HSG examination.

antibiotics, oral contraceptives and gestagenes. In April 1996, HSG was performed because of secondary amenorrhoea. Asherman's syndrome was diagnosed and an intrauterine device (IUD) was inserted into the uterine cavity. The patient was referred to the authors' institution in November 1996 because of metrorrhagia and lower abdominal pain. The IUD was removed from the uterus and 2 months later a control HSG was carried out which showed a hypoplastic uterus deviated to the left. Due to adhesions, an area located on the right side of the uterus was not filled with the contrast fluid. Before the patient was discharged, she was examined by 3D ultrasonography (Combison 530, Kretztechnik) using a 7.5-MHz transvaginal probe. The area that had not been filled with contrast fluid appeared on the 3D picture as an echo-free area (Figure 1). This method also provides the possibility of reconstructing 3D pictures (Figure 2). The hyperechogenic region was still filled with the contrast fluid used in the HSG examination. Our observation with 3D ultrasonography confirmed the diagnosis of Asherman's syndrome.

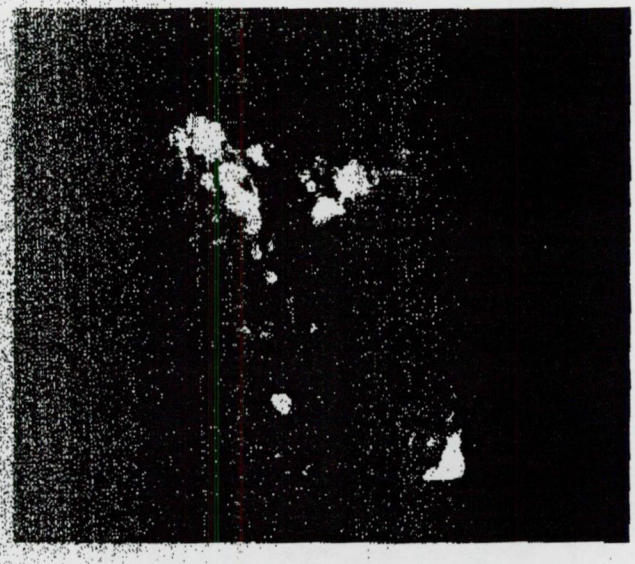


Figure 2 A 3D reconstructed picture of the endometrium. The contrast-free area indicates the synechiae in the endometrium.

Following these examinations, an IUD was inserted into the uterine cavity again, and the anatomic situation was assessed 6 months later by transvaginal 3D sonography. Fewer echo-free areas could be observed in the different planes, and these regions were unambiguously thinner. The IUD could also be located very easily. A 3D reconstruction of the endometrium also showed positive changes in the intrauterine adhesions. As the patient remained undecided regarding future pregnancy, the IUD was left in the uterine cavity. She will continue to be monitored sonographically.

Along with other diagnostic imaging techniques, HSG has been applied primarily to investigate the congenital and acquired anomalies of the female reproductive system. The introduction of other, more advanced diagnostic methods—such as 2D ultrasound, sonohysterography (SHG), hysteroscopy or magnetic resonance imaging (MRI)—has opened up the possibility of choosing the most accurate, least expensive and least patient-burdening technique. Nevertheless, most authors have different views regarding the efficacy of the various technologies[1–3].

By using transvaginal 3D ultrasound, accurate and suitable views of the endometrium can be obtained and displayed, as well as frontal sections of the uterus, which are difficult to visualize by conventional 2D technology. It is also known that 2D and 3D ultrasonography are associated with less discomfort to patients. In the presented case, Asherman's syndrome was diagnosed by HSG; however, the diagnosis could be confirmed by using transvaginal 3D sonography. It was our observation that, in this case, the 3D sonographic technique provided at least as much information about the structure of the endometrium as HSG. Three-dimensional ultrasonography, especially when supplemented with SHG, may be an even better tool for previewing the locations of intrauterine synechiae before potential surgical repair. In addition, fine but significant sheet-like adhesions can also be visualized better by using 3D sonography. Our experiences, which are similar to those of other authors, point to 3D ultrasonography as a very effective, quick and simple method for diagnosing uterine malformations[4].

A. Pal, A. Babinszki, G. Vajda and L. Kovacs
*Department of Obstetrics and Gynecology,*
*Albert Szent-Gyorgyi Medical University,*
*Szeged,*
*Hungary*

*References*

1 Lindheim SR, Sauer MV. Upper genital-tract screening with hysterosonography in patients receiving donated oocytes. *Int J Gynaecol Obstet* 1998; 60: 47–50
2 Gaucheraud P, Piacenza JM, Salle B, Rudigoz RC. Sonohysterography of the uterine cavity: preliminary investigations. *J Clin Ultrasound* 1995; 23: 339–48
3 Pellerito JS, McCarthy SM, Doyle MB, Glickman MG, DeCherney AH. Diagnosis of uterine anomalies: relative accuracy of MR imaging, endovaginal sonography, and hysterosalpingography. *Radiology* 1992; 183: 795–800

# IV.

# Three-Dimensional Measurement of Gestational and Yolk Sac Volumes as Predictors of Pregnancy Outcome in the First Trimester

**Agota Babinszki, M.D.,[1] Tibor Nyari, Ph.D.,[2] Sarah Jordan, R.N.,[1] Ali Nasseri, M.D.,[1] Tanmoy Mukherjee, M.D.,[1] and Alan B. Copperman, M.D.[1]**

**ABSTRACT**

Along with crown-rump length (CRL), the size (diameter) of embryonic structures such as gestational sac (GS) and yolk sac (YS) may have prognostic value for embryonic development. We proposed that first-trimester volume calculations of these structures using transvaginal three-dimensional ultrasound technique may have value as predictors of adverse reproductive outcome. Forty-nine consecutive patients (treated for infertility) with singleton pregnancies were included in this prospective study. Seventy-three examinations were performed in case of pregnancies with normal, and 12 with abnormal outcome. GS and YS volumes were plotted against gestational age (GA) (25–65 days post ovulation) to create nomograms for normal outcome and the same procedure was carried out with CRL measurements as well. Measurements of abnormal pregnancies were compared with these nomograms. Specificity, sensitivity, positive and negative predictive values were also calculated. Regression analysis revealed a power correlation between GS volumes and GA, logarithmic relationship was observed when YS volumes were plotted against GA. CRL showed logarithmic correlation with GA as well. Both GS volumetry and CRL measurements proved to have statistically significant predictive value for adverse outcome ($p < 0.05$). However, no statistically significant difference was found when YS volumes of normal and abnormal pregnancies were compared. Specificity, sensitivity, positive and negative predictive values of GS volumes and CRL were similar. Mean

*American Journal of Perinatology*, Volume 18, Number 4, 2001. Reprint requests: Dr. Babinszki, Department of Obstetrics and Gynecology, University of Szeged, Semmelweis Street 1, Szeged 6725, Hungary. [1]Department of Obstetrics, Gynecology, and Reproductive Sciences, Division of Reproductive Endocrinology, Mount Sinai School of Medicine, New York and [2]Department of Medical Informatics, University of Szeged, Hungary.  0735-1631,p;2001,18,04,203,212,ftx,en;ajp35840x.

YS/GS ratios also had good predictive values ($p < 0.05$). Volume determination of YS and GS can be performed quickly and simply applying three-dimensional sonography. Volumetry of GS proved to be a sensitive predictor for pregnancy outcome and can be a good supplement to CRL measurements.

**KEYWORDS:** Gestational sac, yolk sac, three-dimensional volumetry

Understanding the normal development of early pregnancy and observing this process ultrasonographically has allowed us to monitor effectively first-trimester pregnancy, and recognize early signs of abnormal outcome.[1] Crown-rump length (CRL) has been found the most accurate method to determine gestational age (GA) in the first trimester,[2–4] and in some cases, to predict abnormal outcome as well.[5–7] In addition, the size (diameter) of embryonic structures such as gestational sac (GS) and yolk sac (YS) was also found to have a good prognostic value for adverse outcome.[8–10]

The introduction of more advanced sonographic equipment (probes with higher frequency, higher resolution, new computer techniques, etc.) raised demand for the reevaluation of data to improve accuracy in predicting GA and pregnancy outcome.[1,3] In addition, some authors suggested the creation of nomograms based on the time of ovulation instead of last menstrual period (LMP) to avoid discrepancies in cases in which ovulation did not occur on Day 14.[11,12] During the past few years, the evaluation of the potentials of three-dimensional (3D) ultrasonography has begun and the results are quite promising. This technique combines the advantages of ultrasound and computer tomography (CT), and provides the possibility of acquiring more precise information about the developing pregnancy.[13–15] The acquired images are displayed in three orthogonal planes simultaneously, and these planes can be rotated, computer translated and 3D images can be rendered using this technology. Geometric measurements such as distance, area, and volume can be carried out more accurately.

We proposed that by calculating the volumes of GS and YS in the first trimester using 3D transvaginal sonography, the nomograms of their normal developments could be created and used as the basis of predicting adverse reproductive outcome.

## MATERIALS AND METHODS

Ninety-four examinations were performed in case of singleton pregnancies with normal and 14 with abnormal outcome (first-trimester abortion, blighted ovum) in this prospective study. The patients were all treated for infertility and had known dates of ovulation. The 3D scans were performed with a Voluson 530D (Medison, USA) ultrasound machine using a Voluson Endocavity transducer S-VDW 5–8 (Kretztechnik AG, Austria).

The transvaginal sonographic examination in each case began with the evaluation of the pelvis and the pregnancy in two-dimensional (2D) mode. After switching into 3D volume-mode, the region of interest was defined with the movable sector on the screen and the volume was acquired. Seconds after the acquisition, the scanned region was displayed on the screen in three orthogonal planes (frontal, sagittal, horizontal), and it was checked if the volume contains the whole pregnancy. The information was stored on a 540-MB removable hard disc for subsequent analysis and calculation.

To calculate GS volumes, the "contour" method was used. Starting from the inner margin of the GS, the contour was outlined in the measurement plane using a roller-ball calibrator. The contours were serially selected by viewing the cur-

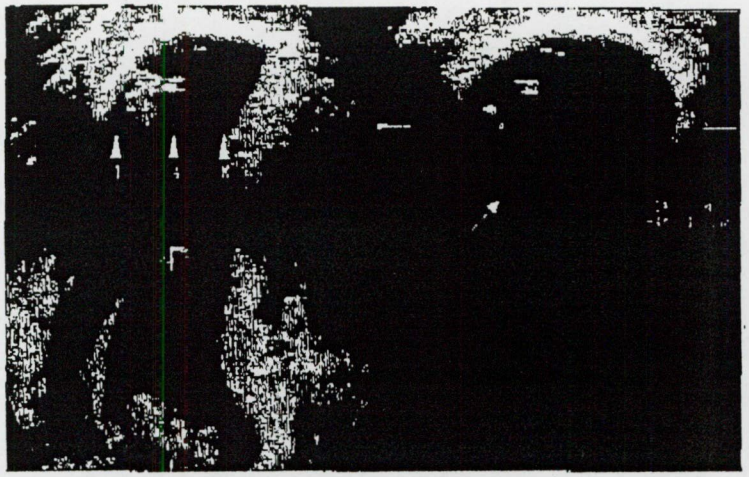


**Figure 1** Display of an 8-week GS in the three perpendicular planes during "contour" type of volumetry. Segments of GS are selected on the fixed upper left plane in the presented case, and the arrowheads indicate the way of the cursor during the calculation procedure. Present status is indicated by arrowhead no. 4. The outline of the actual GS area is drawn on the active/upper right plane in this case (arrow). The lower left plane is also fixed.

sor in another fixed plane moving from pole to pole in the GS (Fig. 1). Seven to fifteen contours were selected depending on the size of the sac. The volume was calculated from these data by the in-built computer immediately. Volumetry of the YS was performed using the "three diameter" method measuring the three diameters of the YS in the three displayed orthogonal planes (Fig. 2). Each calculation of GS and YS volume was repeated three times changing the displayed planes on the monitor between calculations to reduce errors, and the mean of the three measurements was calculated and used afterwards. CRL was also measured three times in different planes when it could be visualized and the calculated mean value was taken into consideration. All calculations were performed by a single examiner (A.B.), who was blinded to obstetrical outcome.

GS and YS volumes as well as CRL were plotted against gestational age (25–65 days post ovulation) to create nomograms for normal outcome. Measurements of pregnancies with abnormal outcome were compared with these curves. Data analysis was performed using SPSS for Win-

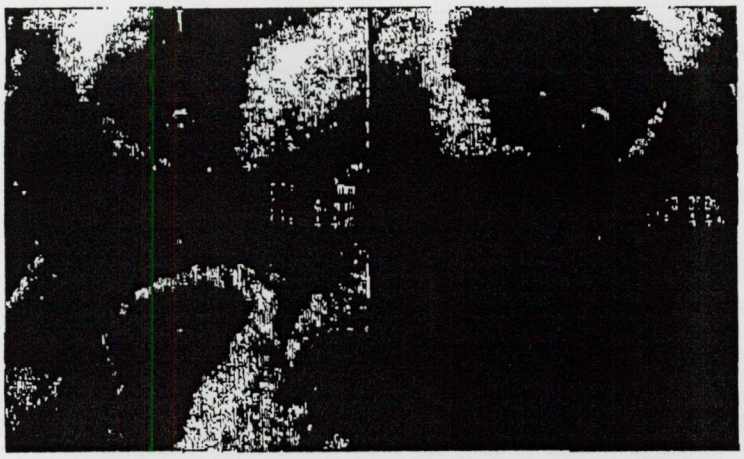


**Figure 2** YS volumes were calculated by using the "three-diameter" volumetric method. The three perpendicular diameters of the YS are measured on the two upper planes in this case.

dows (Version 8.0). Nonlinear regression analysis was used to create growth-curves for normal values (GS, YS, and CRL). Statistical analysis was carried out applying Chi-square and Student *t*-tests. *P* values <0.05 were accepted as indicating statistical significance. Specificity, sensitivity, positive, and negative predictive values of GS volumes and CRL measurements were calculated and compared as well.

## RESULTS

A total of 94 values of GS volume were obtained in pregnancies with normal outcome between the 16 and 65th days post ovulation. However, because of practical reasons only the data from day 25 were used for the regression analysis leaving 73 values to apply (49 patients). The mean and "2SD" limits derived from these GS volume measurements by means of a nonlinear regression analysis was designed to obtain the best fitting curve (Fig. 3). This analysis revealed a power-correlation between GS volumes and GA. Out of the 14 values (obtained from 12 pregnancies) of GS volume with abnormal outcome only 12 (obtained from 11 pregnancies) fell in the 25–65 days post ovulation range. These remaining measurements were fitted in the nomogram (Fig. 3), and 8 of 12 fell beneath the intervals of the curve (two values on Day 25 were very close so their marks on the graph coincide with each other). The prognostic value of GS volumetry for abnormal outcome was found to be statistically significant ($p < 0.05$) and odds ratio (OR) was 4.3 using 95% confidence interval (CI) (95% CI: 1.18–15.91).

Nonlinear regression analysis (using 73 measurements) revealed a logarithmic correlation between YS volumes and GA in case of normal out-

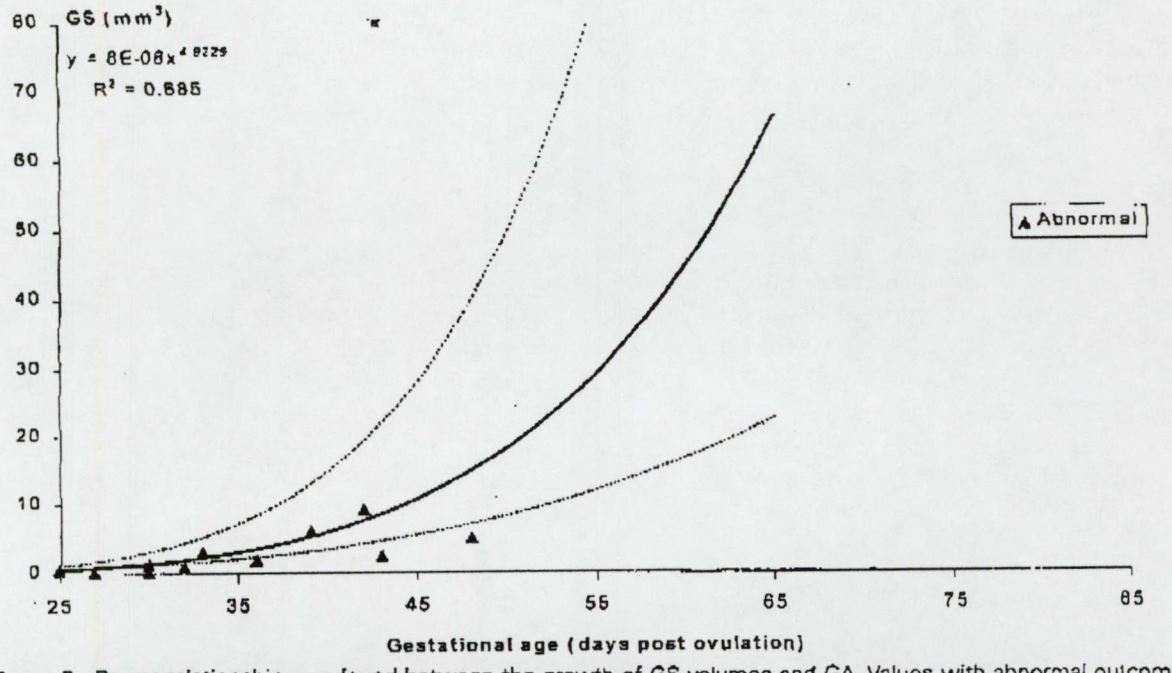



**Figure 3** Power relationship was found between the growth of GS volumes and GA. Values with abnormal outcome are fitted in the nomogram, which was created by using normal values.

come. Eight measurements of YS volumes with abnormal outcome could be obtained. In three cases with abnormal outcome (four missing measurements comparing to the number of GS measurements) because of the shape and/or location of the YS, volumetry could not be executed. Of the eight values only four fell out of the normal range (Fig. 4; the marks of two cases with similar values on Day 25 coincide with each other on the graph). The prognostic value of this method was statistically not significant ($p = 0.07$). Odds ratio was 3.7 (95% CI: 0.83–16.71). A curve for normal CRL growth was also established, using 66 values, to facilitate comparison between the different methods. A logarithmic correlation was found with GA, and predictive value for adverse pregnancy outcome was calculated. Eight cases with first-trimester abortion were applied (Fig. 5), and statistically significant predictive value was found in case of CRL ($p < 0.05$). OR was 5.4 (95% CI: 1.16–25.19). Non-linear regression analysis showed a good diagnostic correlation between GS volumes and CRL because only one case fell outside the intervals of "2SD" of the mean, and $R^2 = 0.79$ (Fig. 6).

Using another method to evaluate and compare the prognostic value of GS, YS volumetry and CRL measurement, the data with abnormal outcome were paired with the normal values on the basis of gestational age and the means of these values in each group were calculated and compared (Table 1). Naturally, only those values could be used in this comparison, which had their matching pairs in terms of the GA. GS volumes and CRL were found to have statistically significant prognostic value for first-trimester abortion by this method.

Similar specificity, sensitivity, positive and negative predictive values of GS volumetry and CRL measurements were found regarding pregnancy outcome (Table 2). However, when the re-

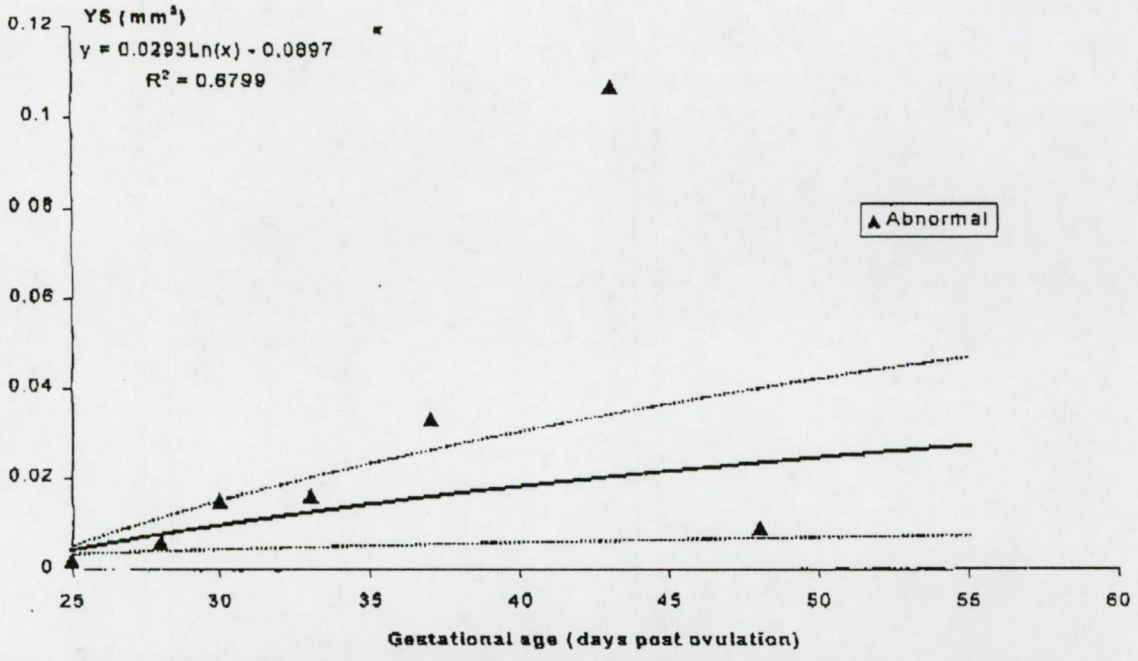



**Figure 4** *The correlation between YS volumes and GA showed logarithmic pattern. Cases with abnormal outcome are presented in the graph.*

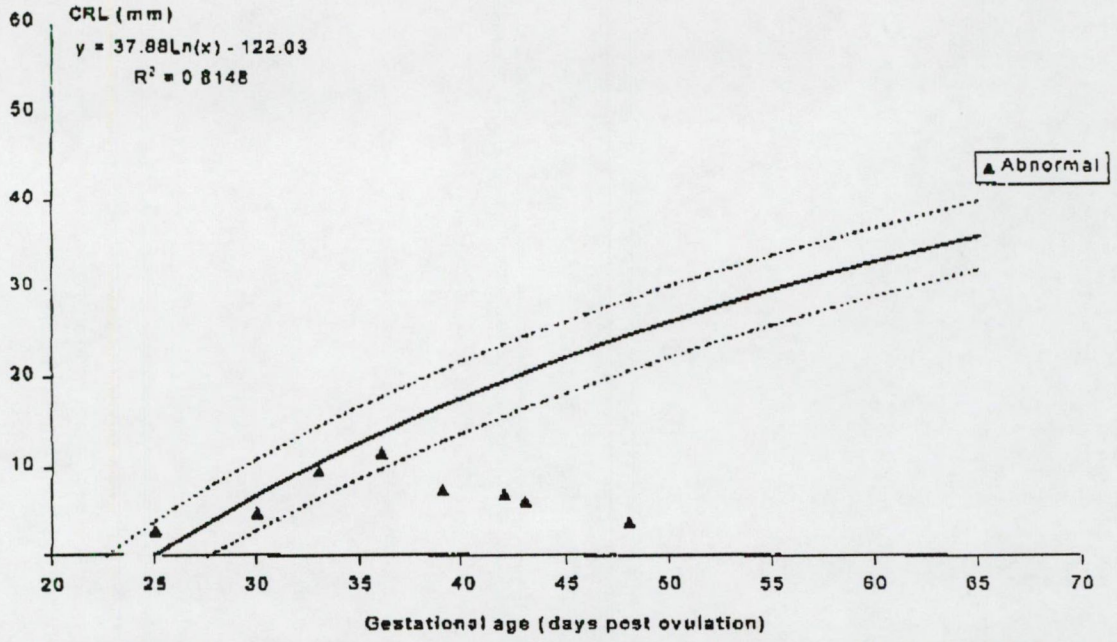



**Figure 5** Logarithmic relationship was found between CRL growth and GA and cases with adverse outcome are evaluated by using this nomogram.

sults of the two methods correlated with each other, specificity and positive predictive value could be improved (Table 2).

Mean YS/GS ratios were also calculated in both the normal and the abnormal groups to facilitate comparison. The mean YS/GS ratio was 0.02 in case of normal and 0.05 in case of abnormal outcome and the difference was statistically significant ($p < 0.05$).

## DISCUSSION

First-trimester sonographic evaluation of the pregnancy provides important information about embryonic viability, and accurately predicts gestational age. Observation of normally developing pregnancies has allowed us to predict abnormal outcome. Detailed descriptions of embryonic structures are available for the traditional 2D[1] and even the more recently introduced 3D ultrasound technique.[13–15] Normal growth curves for CRL, GS, and YS were established as early as the first years of the 1970s using 2D ultrasound,[2,4] although modifications of these nomograms were carried out simultaneously with the improvement of sonographic technology.[1,3,16,17] GS diameter, CRL, and the measurement of YS were found to be sensitive predictors for abnormal outcome in the first trimester in numerous studies.[5–10] Nevertheless, a few authors observed that YS size has no prognostic value for embryonic demise and pregnancy outcome.[18,19] Some studies found that the ratio of GS size:CRL might be a reliable method of predicting first trimester abortion.[20,21] We undertook this prospective study to evaluate the predictive value of early gestational sac and yolk sac volumetry.

Robinson et al[4] created the first graph for GS volume–growth performing the measurements with a 2D ultrasound machine and using mathematical formula to calculate volumes. They found

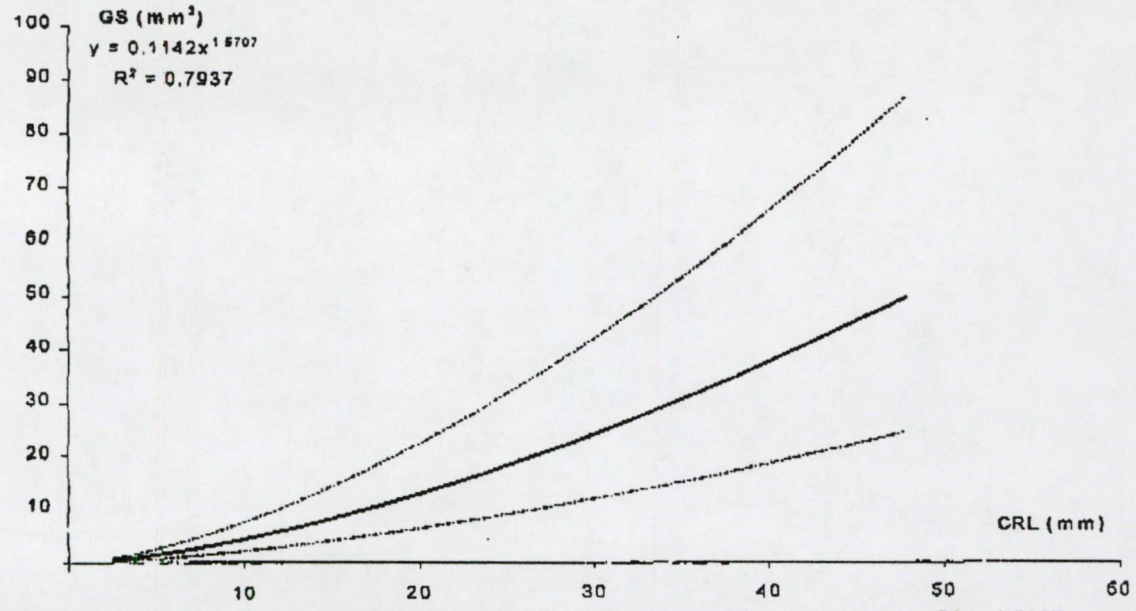



**Figure 6** Power correlation was revealed between GS volumetry and CRL measurements. $R^2 = 0.7937$ proves the similar diagnostic potentials of the two methods.

exponential correlation between GS volumes and GA until 10 weeks that became a more linear correlation during the 11–13th weeks of pregnancy. The first and only volumetric evaluation of first-trimester pregnancy using 3D ultrasound so far is a small pilot study by Steiner et al.[13] They applied transabdominal 3D sonography and described a linear correlation between GS volumes and GA using 31 measurements. They found, that three-fifths cases of missed abortion and blighted ovum had a GS volume <2 SD of the mean. Positive predictive value was 100% and negative predictive value was 97% in that study.

Our study established nomograms for GS and YS volumes in the first trimester using 73 values and compared the predictive value of these variables for pregnancy outcome with that of CRL. The purpose of this present study was to find the best predictor for adverse outcome that can be used in routine diagnostics. Power correlation was

**Table 1 Values with Abnormal and Normal Outcome Matched on the Basis of GA in the Three Groups**

| Outcome | Case No. | Mean ± SD | p |
|---|---|---|---|
| CRL | | | <0.05 |
| NA | 20 | 15.9 ± 7.2 | |
| A | 8 | 6.6 ± 2.9 | |
| GS | | | <0.05 |
| NA | 32 | 6.2 ± 8.1 | |
| A | 12 | 2.1 ± 2.7 | |
| YS | | | NS |
| NA | 26 | 0.014 ± 0.009 | |
| A | 8 | 0.038 ± 0.069 | |

NA, nonaborters; A, aborters.

**Table 2 Prognostic Value of GS Volumetry and CRL Measurements***

| | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) |
|---|---|---|---|---|
| GS volumetry | 67 | 68 | 26 | 93 |
| CRL | 62 | 74 | 23 | 94 |
| GS+CRL | 60 | 88 | 43 | 94 |

*GSV+CRL is analyzed when predicting similar outcome.
PPV, positive predictive value; NPV, negative predictive value.

observed between GS volumes and GA (calculated from the time of ovulation), and logarithmic correlation when YS volumes were plotted against GA. The relationship between GS diameter and GA as well as CRL and GA was found to be linear in the literature and curvilinear in case of YS diameter and GA.[2,16-18] The graph of CRL and GA showed a logarithmic correlation in the present study.

Using the created nomograms, GS volume and CRL proved to have good negative predictive values for first-trimester abortion, while YS volumetry did not appear to be a reliable predictor in our study. In addition, when cases with abnormal outcome were paired with normals on the basis of GA and the mean values of aborters and nonaborters were compared in the three groups, similar results were observed. It is difficult to determine, whether YS volume (in case of normal appearing YS) being a noninformative predictor is due to the small case-number with adverse outcome.

The diagnostic value of GS volumetry and CRL measurements were found to be similar when they were compared by nonlinear regression analysis as well as by calculating sensitivity, specificity, positive and negative predictive values. It was found that combinatory application of these methods improves specificity and positive predictive value in case they predict similar outcome. In case GS volume and CRL measurements are contradictory, close follow-up is necessary and suggested to find out if the pregnancy is endangered. Nevertheless, positive and negative predictive values were lower than in the study by Steiner et al.[13] When the mean YS/GS ratios were calculated in both groups, we found the prognostic value of this ratio to be a reliable variable because it was statistically significantly higher in the abnormal group.

On the basis of our observations we can conclude that GS volumetry as a predictor can be a good supplement to CRL measurements using 3D transvaginal ultrasonography in the first trimester. This technology provides the possibility of acquiring accurate information in a few seconds. Applying 3D technology, direct volumetric calculations can be carried out precisely and quickly, and it allows the examiner to accurately evaluate the shape and morphology of embryonic structures. If validated by further studies, 3D volumetric results may enable us to predict first-trimester pregnancy loss earlier and more accurately.

ACKNOWLEDGMENT

The authors thank MEDISON, USA for their generosity in allowing them to use this three-dimensional ultrasonographic machine (Voluson 530D) for educational and study purposes.

## REFERENCES

1. Jurkovic D, Gruboeck K, Campbell S. Ultrasound features in normal early pregnancy development. Curr Opin Obstet Gynecol 1995;7:493–504
2. Robinson HP, Fleming JEE. A critical evaluation of sonar "crown-rump length" measurements. Br J Obstet Gynaecol 1975;82:702–710
3. Hadlock FP, Shah YP, Kanon DJ, Lindsay JV. Fetal crown-rump length: reevaluation of relation to menstrual age (5–18 weeks) with high-resolution real-time US. Radiology 1992;182:501–505
4. Robinson HP. "Gestational sac" volumes as determined by sonar in the first trimester of pregnancy. Br J Obstet Gynaecol 1975;82:100–107
5. Mantoni M, Pedersen JF. Fetal growth delay in threatened abortion: an ultrasound study. Br J Obstet Gynaecol 1982; 89:525–527
6. Nazari A, Check JH, Epstein RH, Dietzerich C, Farzanfar S. Relationship of small-for-dates sac size to crown-rump length and spontaneous abortion in patients with a known date of ovulation. Obstet Gynecol 1991;78:369–373
7. Cunningham DS, Bledsoe LD, Tichenor JR, Opsahl MS. Ultrasonographic characteristics of first-trimester gestations in recurrent spontaneous aborters. J Reprod Med 1995;40:565–570
8. Lindsay DJ, Lovett IS, Lyons EA, et al. Yolk sac diameter and shape at endovaginal US: predictors of pregnancy outcome in the first trimester. Radiology 1992;183:115–118
9. Stampone C, Nicotra M, Muttinelli C, Cosmi EV. Transvaginal sonography of the yolk sac in normal and abnormal pregnancy. J Clin Ultrasound 1996;24:3–9
10. Ferrazzi E, Brambati B, Lanzani A, et al. The yolk sac in early pregnancy failure. Am J Obstet Gynecol 1988;158: 137–142
11. MacGregor SN, Tamura RK, Sabbagha RE, Minogue JP, Gibson ME, Hoffman DI. Underestimation of gestational age by conventional crown-rump length dating curves. Obstet Gynecol 1987;70:344–348

12. Evans J. Fetal crown-rump length values in the first trimester based upon ovulation timing using the luteinizing hormone surge. Br J Obstet Gynaecol 1991;98:48–51
13. Steiner H, Gregg AR, Bogner G, Graf AH, Weiner CP, Staudach A. First trimester three-dimensional ultrasound volumetry of the gestational sac. Arch Gynecol Obstet 1994;255:165–170
14. Merz E, Bahlmann F, Weber G, Machiella D. Three-dimensional ultrasonography in prenatal diagnosis. J Perinat Med 1995;23:213–222
15. Bonilla-Musoles F, Raga F, Osborne NG, Blanes J. Use of three-dimensional ultrasonography for the study of normal and pathologic morphology of the human embryo and fetus: preliminary report. J Ultrasound Med 1995;14: 757–765
16. Rossavik IK, Torjusen GO, Gibbons WE. Conceptual age and ultrasound measurements of gestational sac and crown-rump length in in vitro fertilization pregnancies. Fertil Steril 1988;49:1012–1017
17. Goldstein I, Zimmer EA, Tamir A, Perets BA, Paldi E. Evaluation of normal gestational sac growth: appearance of embryonic heartbeat and embryo body movements using the transvaginal technique. Obstet Gynecol 1991;77: 885–888
18. Reece EA, Scioscia AL, Pinter E, et al. Prognostic significance of the human yolk sac assessed by ultrasonography. Am J Obstet Gynecol 1988;159:1191–1194
19. Jauniaux E, Jurkovic D, Henriet Y, Rodesch F, Hustin J. Development of the secondary human yolk sac: correlation of sonographic and anatomical features. Hum Reprod 1991;6:1160–1166
20. Tadmor OP, Achiron R, Rabinowitz R, Aboulafia Y, Mashiach S, Diamant YZ. Predicting first-trimester spontaneous abortion: ratio of mean sac diameter to crown-rump length compared to embryonic heart rate. J Reprod Med 1994;39:459–462
21. Goldstein SR, Subramanyam BR, Snyder JR. Ratio of gestational sac volume to crown-rump length in early pregnancy. J Reprod Med 1986;31:320–321